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Response of liquid bio-fertilizers on growth, yield attributing characters and economics of little millet (*Panicum sumatrense* Roth) under Marhan (Upland) situations

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Abstract
A study was conducted on little millet to investigate the effect of little millet (*Panicum sumatrense* Roth) growth, yield and economics as affected by liquid biofertilizers and their mode of application at New Upland Research cum Instructional Farm (NURI), Lamker under S. G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh, India during *Kharif,* 2021. The experiment was carried out in randomized bock design with three replications using in various permissible combinations of 100%, 85% and 70% RDF with different mode of application of biofertilizer as seed treatment, soil application and combination of both. T_1,100% RDF + Seed treatment with liquid biofertilizer (5 ml kg^{-1} seed) followed by soil application o liquid biofertilizer (3 litter, mix with 5 t FYM and apply in furrows at sowing for one ha area) gave significantly higher grain yield, Straw yield and yield attributing character and growth character as compared to other treatment. The treatment combination with 100% RDF + Soil application of biofertilizer and 85% RDF + seed treatment + soil application of biofertilizer were found at par with this treatment T_1. These results indicate that inorganic fertilizers along with biofertilizers (seed treatment + soil application) proved to be useful in achieving the higher yield and net returns.

Keywords: Little millet, biofertilizer, yield, economics

1. Introduction
Small millets are a traditional crop, and they are best suited for agriculturally poor soils. Finger millet, Kodo millet, Little millet, Foxtail millet and Barnyard millet are the most common small millets in India. Millet grains have long been a staple food for traditional Indian and African consumers and low-income populations, as well as a staple food in many modern countries Malleshi, N.G. 1997 [20]. Millets seeds are tiny in size, round in shape and minor cereals of the small seeded-grass family (Poaceae). It is characterized by their remarkable ability to survive in less fertile soil, drought tolerant, resistance to pests and diseases, short growing period Devi *et al*. 2014 [11] and can be very well fitted into multiple cropping systems both under irrigated as well as dry farming conditions. Millets are also unique due to their short period of production. Millets are amazing in their nutrition content Subramanian *et al*. 2010 [31] and Trivedi *et al*. 2015 [33].
Little millet belongs to the genus *Panicum* having a chromosome number of 2n = 36, with basic chromosome number of x = 9. It was domesticated in India De Wet *et al.*, 1983 [10]. Its high fiber content aids in the reduction of fat deposits in the body. Per 100 gram of little millet, there are 8.7 g of protein, 75.7 g of carbohydrates, 5.3 g of fat, and 1.7 g of minerals Annonymus, 2017. [2] Little millet is highly nutrition and may be called little but it not less in its nutritional content. It has good source of B vitamin, minerals like calcium, iron, zinc, potassium among others. The average productivity of small millets including little millet is less, but presently improved varieties have been developed which are having enough potential. Choices of proper agronomic management are key concerns to maximize productivity of little millet and research in the line of agronomic management may be intensified.
Nitrogen, phosphorus and potassium are the essential elements required for plant growth in relatively large amounts for better performance in crop growth Dhhwayo and whhgwin, 1984 [12]. These crops respond very well even to recommended doses of fertilizers and other crop management inputs, which do not involve additional expenditure, such as sowing at the optimum time, maintenance of adequate plant stand, timely weeding, and inter cultivation Sapthagiri *et al.*, 2020 [28].

Bio fertilizer is a biological product which contains living microorganisms which, when applied to seed, plant surfaces, or soil, promote growth by several mechanisms such as increasing the supply of nutrients increasing root biomass or root area and increasing nutrient uptake capacity of plant Vessy, 2003. The role of bio-fertilizers alone or in combination with organic or inorganic fertilizers has recently gained recognition in sustainable crop production Kennedy *et al*., 2004 [18], Bloemberg *et al.*, 2000 [6] and Abdullahi and Sheriff, 2013. Application of bio-fertilizer not only fixes the biological nitrogen but also solubilizes the insoluble phosphates in soil and thus improves nutrient availability. Since fertile soil is the fundamental resource for higher production, its maintenance is a prerequisite for long term sustainable crop production which cannot be maintained by using chemical fertilizers alone and similarly, it is not possible to obtain higher crop yield by using only organic manure Bair, 2000 [4].

It is worth mentioning that nutrient management through organic sources plays a major role in maintaining soil health as it improves the status of soil organic matter, beneficial microbes and enzymes besides improving soil physical and chemical properties Raviraja *et al.*, 2020 [27]. Therefore, the aim of the experiment was taken to assess the effects of liquid bio-fertilizers and their mode of application on little millet to evaluate its growth yield potential and economics for its cultivation.

2. Material and Methods

2.1 Experimental site: A field experiment on little millet was performed during *Kharif*, 2021 from last week of June to October, 2021 at the New Upland Research cum Instructional Farm (NURI), Lamker under S. G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh, India at the geographical co-ordinates latitudes of $19^0$13'28.21" N and $81^0$52'44.40" E longitude elevation 561 MSL. The area falls under India's Eastern plateau and hills region, which is classed as subtropical humid with hot summers and cold winters. The rain comes from the south-western monsoon. During the experimental season, the average rainfall was 897 mm, with 52 rainy days and the maximum temperature was 30.00 °C and the minimum temperature was 22.30 °C, with relative humidity of 72-92 per cent, respectively received with an average of 3.07 hours of bright sunshine hours.

2.2 Soil sampling: A composite soil sample was collected from the experimental site from 0–15 cm soil profile depth for the pre-experimental soil Physico-chemical analysis, following the standard procedures. A fraction of this composite sample was also used for the mechanical analysis of soil by International pipette method (Table 1). Another part of the composite sample taken from the main field was air dried at room temperature, powdered to pass through 70 mesh (1.6 mm) sieve and was used for chemical analysis. The result obtained from the chemical analysis was compared with rating chart given by Muhr *et al.*, 1963 [22].

Table 1: Analyzed results for initial chemical properties of the soil

Sl. No.	Particulars	Obtained observation	Range	Method adopted
1.	pH (1:2.5 Soil: water)	5.69	Low	Glass electrode pH meter (Piper, 1967) [23]
2.	EC (dS m^{-1})	0.09	Medium	Solubridge conductivity method, (Black,1965) [5]
3.	Organic Carbon (%)	0.40	Medium	Walkley and Black's rapid titration method (Black, 1965) [5]
4.	Available N (kg ha^{-1})	161.36	Low	Alkaline permanganate method (Subbiah and Asija, 1956) [30]
5.	Available P (kg ha^{-1})	18.78	Very Low	Bray no.1: for acid soil (Bray, 1948) [7]
6	Available K (kg ha^{-1})	207.17	High	Neutral normal ammonium acetate extraction and determined flame photometrically (Jackson, 1967) [7]

2.3 Experiment Design and Treatment

The experiment was conducted on New Upland Research cum Instructional Farm, Lamker under SGCARS, Jagdalpur (Bastar). The experimental design was used randomized block design (RBD) with three replications. The treatments were comprised of eleven treatments *viz.*, T_1: 100% RDF + Seed treatment with liquid bio-fertilizer (5 ml kg^{-1} seed) followed by soil application of liquid bio-fertilizer (3 liter, mix with 5 t FYM and apply in furrows at sowing for one hectare area), T_2: 100% RDF + Seed treatment with liquid bio-fertilizer (5 ml kg^{-1} seed), T_3: 100% RDF + Soil application of liquid bio-fertilizer (3 liter, mix with 5 t FYM and apply in furrows at sowing for one hectare area), T_4: 85% RDF + Seed treatment with liquid bio-fertilizer (5 ml kg^{-1} seed) followed by soil application of liquid bio-fertilizer (3 liter, mix with 5 t FYM and apply in furrows at sowing for one hectare area), T_5: 85% RDF+ Seed treatment with liquid bio-fertilizer (5 ml kg^{-1} seed), T_6: 85% RDF + Soil application of liquid bio-fertilizer (3 liter, mix with 5 t FYM and apply in furrows at sowing for one hectare area), T_7: 70% RDF + Seed treatment with liquid bio-fertilizer (5 ml kg^{-1} seed) followed by soil application of liquid bio-fertilizer (3 liter, mix with 5 t FYM and apply in furrows at sowing for one hectare area), T_8: 70% RDF + Seed treatment with liquid bio-fertilizer (5 ml kg^{-1} seed), T_9: 70% RDF + Soil application of liquid bio-fertilizer (3 liter, mix with 5 t FYM and apply in furrows at sowing for one hectare area), T_{10}: Recommended dose of fertilizer and T_{11}: Absolute control.

2.4 Statically methods

All the observations recorded of pre and post-harvest during different intervals with respect to various growth periods, yield and laboratory studies were subjected to statistical analysis as per the procedure laid down by Gomez and Gomez, 1984 [15].

3. Result and Discussion

3.1 Plant height (cm)

Effect of liquid bio fertilizers on plants height are presented in Table 2. The data shows that treatment T_1 recorded significantly taller plant at all the growth stages but treatment T_4, T_3 and T_2 produced on par with treatment T_1 and smaller plant was observed in treatment T_{11} at all the growth stages. This might be due to increased uptake of nitrogen and phosphorus by the plants, which was made available through nitrogen fixation and phosphate solubilisation by the microorganisms. Nitrogen enhanced the vegetative growth of the plant thus, leading to significant increase in plant height. The result obtained by Upadhaya *et al.*, 2022 [34], Rani *et al.*, 2019 [25], Rathore and Gautam, 2003 [26], Choudhary and

Gautam, 2007 [8] and Latake *et al.,* 2009 [19] supports these findings.

3.2 No. of productive tillers plant^{-1}

Table 2 reveals that number of productive tillers plant^{-1} was affected by different liquid biofertilizers. The data reveals that treatment T_1 was observed significantly higher number of productive tillers plant^{-1} at all the growth stages but treatment T_4, T_3 and T_2 also produced on par with treatment T_1. Whereas, treatment T_{11} was recorded minimum number of productive tillers at all the growth stages. This might be due to higher rate of fertilizer application along with application of biofertilizer through soil and seed treatment leads to increase the nutrient availability to the plant resulted in increase in number of tillers compare to lower fertility levels and non-application of biofertilizers, these results are also corroborated with Upadhaya *et al.,* 2022 [34] and Latake *et al.,* 2009 [19].

3.3 Dry matter accumulation (g plant^{-1})

Table 2 shows that dry weight accumulation was effected by different liquid biofertilizers. The data found that treatment T_1 produced significantly higher dry matter accumulation at all the growth stages but treatment T_4 produced on par at all the growth stages except at 30 DAS. Treatment T_3 was also found similar with treatment T_1 at 60 DAS and at harvest, but treatment T_2 was produced on par with T_1 at harvest. Lowest dry matter accumulation was observes in treatment T_{11} which was absolute control at all the growth stages. This might due to increase in fertility level along with application of biofertilizer through soil and seed treatment, these results are also similar findings by Prabudoss *et al.,* 2014 [24], Upadhaya *et al.,* 2022 [34], Singh *et al.,* 2017 [29] and Rani *et al.,* 2019 [25].

3.4 Days to 50% flowering

Table 2 the data noticed that days to 50% flowering was recorded statically non-significant effect due to different liquid biofertilizers treatments, but numerically early flowering was initiated in treatment T_{11} and late flowering was observed in treatment T_1 as compared to all the treatments. This might be due to increase in nitrogen dose, the days to 50% flowering increased. The result was also supported by Upadhaya *et al.,* 2022 [34], Damame *et al.,* 2013 [9] and Divya *et al.,* 2017 [13].

3.5 Days to maturity

Table 2 the data proved that days to maturity was recorded statically non-significant due to different liquid biofertilizers treatments, but numerically early was maturity recorded in treatment T_{11} which was absolute control and late maturity was found in treatment T_1 as compared to all the treatments. This might be due increase of nitrogen dose, nitrogen is responsible for succulence of the plant and it delayed maturity in those treated with higher dose. Upadhaya *et al.,* 2022 [34] and Damame *et al.,* 2013 [9] both have also corroborated the similar results in foxtail millet and pearl millet.

3.6 Length of panicle (cm) and Panicle weight (g)

Table 3 reveals that panicle length and panicle weight was affected by different liquid biofertilizers treatments. The data shows that treatment T_1 was recorded significantly higher in panicle length but treatment T_3, T_2 and T_4 was found on par with treatment T_1. This might be due to the balanced supply of NPK and FYM mix with liquid biofertilizer through soil and seed treatment. The result obtained by Monisha *et al.,* 2019 [21], Husain *et al.,* 2017 [16], Latake *et al.,* 2009 [19] and Divya *et al.,* 2017 [13] supports these findings.

3.7 No. of seeds panicle^{-1}

Table 3 found that number of seeds panicle^{-1} was affected by different liquid biofertilizers treatments. The data proved Treatment T_1 was produced maximum number of seeds panicle^{-1} among all the treatments but treatment T_3, T_4 and T_7 was found significantly on par with treatment T_1 and minimum seeds per panicle were recorded in treatment T_{11} which was absolute control. The result obtained by Upadhaya *et al.,* 2022 [34] supports these findings.

3.8 1000 seed weight (g)

Table 3 indicates that test weight was not- significantly influenced by different liquid biofertilizers treatments. The data expressed the utmost test weight in treatment T_1 and minimal in treatment T_{11}. These results were similar finding reported by (Upadhaya *et al.,* 2022) [34].

3.9 Grain and straw yield (kg ha^{-1})

Effect of different liquid bio fertilizers on grain and straw yield are presented in Table 4. The data shows that treatment T_1 produced significantly higher economic yield among all the treatments, but treatment T_3 and T_4 was observed similar result with treatment T_1. Whereas T_{11} which was recorded lowest grain and straw yield at all the treatments. The balanced supply of FYM and NPK might have increased all the growth parameter, yield attributing characters which ultimately contributed to increase in yields; these results are also similar findings by Gawade *et al.* (2013) [14], Thumar *et al.,* 2016 [32], Choudhary and Gautam, 2007 [8], Latake *et al.,* 2009 [19], Singh *et al.,* 2017 [29] and Rani *et al.,* 2019 [25].

3.10 Harvest index (%)

Effect of different liquid bio fertilizers on harvest index are presented in Table 4. The data noticed that harvest index recorded non-significant due to effect of different liquid biofertilizer treatments but numerically treatment T_1 recorded numerically highest harvest index and lowest harvest index was recorded in T_{11}, Similar result was reported by Upadhaya *et al.,* 2022 [34].

3.11 Gross income (Rs. ha^{-1}), Net income (Rs. ha^{-1}) and Benefit cost ratio

Effect of different liquid bio fertilizers on economics are presented in Table 4. The data proved that treatment T_1 produced maximum gross income, net income and benefit cost ratio among all the treatments and treatment T_{11} was recorded minimum gross income, net income and benefit cost ratio. The higher gross return, net return and B:C ratio was found due to the fact that this fertility levels along with mode of biofertilizer application provided better nutritional environment resulted in higher productivity of grain as well as straw resulted in better return, Similar result was reported by Upadhaya *et al.,* 2022 [34], Choudhary and Gautam, 2007 [8], Latake *et al.,* 2009 [19], Singh *et al.,* 2017 [29], Ashwani and Rajesh, 2017 and Rani *et al.,* 2019 [25].

Table 2: Response of liquid biofertilizers and their mode of application on growth of little millet

Treatment	Plant height (cm)	Dry matter accumulation (g plant^{-1})			No. of tillers plant^{-1}	Days to flowering	Days to maturity
		30 DAS	60 DAS	At harvest			
T_1	126.07	2.31	5.62	8.06	3.07	61.23	93.60
T_2	117.13	1.62	4.44	6.18	2.73	59.58	91.50
T_3	118.33	1.90	5.01	7.07	2.87	60.14	92.29
T_4	120.67	1.98	5.11	7.11	2.93	61.15	92.75
T_5	109.63	1.09	3.03	4.40	2.33	58.74	91.19
T_6	112.73	1.19	3.26	4.72	2.40	59.25	92.12
T_7	116.13	1.63	3.99	5.73	2.53	60.52	92.22
T_8	106.13	0.75	2.21	3.27	2.20	58.04	90.98
T_9	108.93	0.95	2.69	3.94	2.27	58.52	91.07
T_{10}	113.73	1.46	3.46	4.98	2.47	60.33	92.00
T_{11}	92.53	0.57	1.78	2.67	1.80	57.55	89.72
S.Em±	3.46	0.09	0.27	0.38	0.15	0.87	0.84
C.D	10.27	0.28	0.80	1.13	0.44	NS	NS

Table 3: Response of liquid biofertilizers and their mode of application on yield attributes of little millet

Treatment	Panicle length (cm)	Panicle weight (g)	No. of seeds panicle^{-1}	Test weight (g)
T_1	24.80	1.48	404	2.53
T_2	23.07	1.43	336	2.42
T_3	24.20	1.45	388	2.50
T_4	22.60	1.37	387	2.44
T_5	21.13	1.27	328	2.40
T_6	22.33	1.33	355	2.38
T_7	22.27	1.26	373	2.37
T_8	19.87	1.06	281	2.29
T_9	20.67	1.12	331	2.31
T_{10}	22.00	1.17	364	2.35
T_{11}	18.53	0.91	306	2.25
S.Em±	0.89	0.06	12.39	0.07
C.D	2.62	0.18	36.80	NS

Table 4: Response of liquid biofertilizers and their mode of application on yield and economics of little millet

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI (%)	Gross Return (Rs ha^{-1})	Net Return (Rs ha^{-1})	B: C ratio
T_1	1498	2582	36.71	46217	18441	1.66
T_2	1024	1837	35.86	31648	10472	1.49
T_3	1375	2444	36.19	42479	14708	1.53
T_4	1329	2397	35.67	41071	13618	1.49
T_5	878	1609	35.35	27153	6211	1.30
T_6	972	1771	35.52	30049	2601	1.10
T_7	1080	1914	36.01	33369	6206	1.23
T_8	657	1238	34.66	20317	-425	0.98
T_9	828	1550	34.86	25631	-1527	0.94
T_{10}	1007	1781	36.17	31099	9928	1.47
T_{11}	589	1175	33.41	18265	-1460	0.93
S.Em±	72	148	0.61			0.08
C.D	213	441	NS			0.25

4. Conclusion

Based on the findings of the current study, it can be concluded that applying 100% RDF + seed treatment with liquid bio-fertilizer (5 ml kg^{-1} seed) followed by soil application of liquid biofertilizer (3 litre, mix with 5 t FYM, and apply in furrows at sowing for one hectare area).

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